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orld is utilized for livestock feed or human food in the countries where grown.

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FRONT COVER

A Rye Field in Poland

In Poland, one of the great rye-producing countries, both hand labor and machines are used. (Photo by courtesy of F. A. O.)

BACK COVER

World Map—Distribution of Rye Production

The Soviet Union accounted for more than half the world's prewar rye production. In 1947 the Soviet crop was somewhat larger, but the total of all other producing areas declined so that the Soviet Union's share of the world crop was almost two-thirds.

NEWS NOTES

Dr. Robbins Tours Latin America

Dr. W. W. Robbins, Professor of Botany, College of Agriculture, University of California, is on a Latin American tour under the Department of State's program of International Exchange of Persons, cooperating with a request of this Department that Dr. Robbins confer with interested agricultural agencies and persons in the other American Republics. Dr. Robbins specializes in weed control and related subjects and will lecture on phases of his specialty while on tour.

4-H Group in England

The first group under the International Farm Youth Exchange project, assigned to Great Britain, recently met in Washington the Maryland 4-H Dairy Judging Team, which is to assist at the Royal Livestock Show in England. Together they journeyed to New York and sailed on the Marine Tiger early in June.

Dr. Pendleton Attends Soils Conference in England

Upon invitation of His Majesty's Government, *Robert L. Pendleton*, Soils Scientist, is attending a conference on tropical soils in England. The meeting was scheduled to be held at the Rothamsted Experiment Station.

Fats and Oils Specialist to Make Market Survey

Howard A. Akers, Marketing Specialist, Fats and Oils Branch, PMA, was assigned to this Office for a short time and then left Washington on August 1 to make a market survey of western Europe. His itinerary included several European and a number of African countries.

BAE Specialist on Loan to OFAR

George C. Edler, Bureau of Agricultural Economics, was loaned to this Office for work under the Research and Marketing Act. He left for Europe in July to study the production of, and market for, vegetable and field-crop seeds in the western and central countries of that continent. He will return to Washington early in the fall.

Illustrations in pages 164 and 166 were furnished by courtesy of F. A. O.

FOREIGN AGRICULTURE — HALLY H. CONRAD, EDITOR

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Rye—A Source of Daily Bread

Among the bread-eating peoples of the world, consumer preference may be for wheat bread, but the hungry are grateful also for rye bread. It may, in many instances, mean the difference between starvation and survival in the world of today.

by **LEO J. SCHABEN**

Down through the centuries, most of the human race has depended upon wheat, rye, or rice as the basic and most important staple item in its diet. The use of other grains, such as corn, millet, sorghums, barley, and buckwheat, for human food was, and still is, relatively small and usually confined to only a few countries or areas in those countries. The relative importance of any one, or more, of the grains in the food supply and in the agriculture and national economy of the countries or regions of the world is determined by a number of factors. Included among them are prevailing conditions of climate, soil, and topogaphy; food- and feed-yielding capacities of the various grains; consumer preferences for various uses in the different countries; purchasing power and standards of living of the people; production and marketing costs; governmental policies; and world market prices.

Being especially adapted to growing conditions in hot and wet climates, rice always has been the principal food crop in Monsoon areas of the Orient, which contain approximately one-half the population of the earth. Correspondingly, being especially adapted to growing conditions in the drier and cooler regions of the earth, wheat or rye constitutes the principal item in the diet of the remaining half of the world's population. Wheat and rye, therefore, are to the people of the Occident what rice is to those of the Orient, "the staff of life."

In botanical relationships, physiological characteristics, habit of growth, and manner of cultivation rye is a cereal that is similar to wheat. Like wheat, it can be sown in the fall of the year for harvesting early in the following summer, or it can be sown in the spring of the year for harvesting later in the season. By far the larger part of the world's production, however, consists of winter rye, because winter rye gives larger yields and is generally superior in quality to spring rye. The original home of rye appears to have been in the region between the Austrian Alps and the Caspian Sea or in the foothills adjacent to the Mediterranean. Its production first became of great economic significance in the Middle Ages; by the middle of the nineteenth century it was the world's chief bread-making grain. Since then, it has been increasingly replaced by wheat.

Leo J. Schaben is Agricultural Economist in the Grain Division, International Commodities Branch, OFAR.

Rye as a Foodstuff

The major use of rye has always been for bread making. Rye and wheat are referred to as bread grains, because they are the only grains from which common or leavened bread with its characteristic porous loaf can be made. This is due to the fact that some of the proteins in rye, as in wheat, are in the form of gluten which makes the dough tough and elastic. As a result, the gas bubbles formed in the dough during the process of fermentation are retained, making the dough rise and increase in volume. The pores containing these gases are solidified and made permanent by the heat in baking. Rye flour is, however, somewhat inferior to wheat flour in the quantity and quality of the proteins present in it. Consequently, dough made entirely from rye flour retains a much smaller quantity of the gases than that made from wheat flour, and a loaf of rye bread from the same quantity of flour does not have the volume and fine texture of a loaf of wheat bread.

Though displaying marked differences with respect to color and flavor, rye is similar to wheat in chemical content, and the bread made from it possesses virtually the same nutritional value as wheat bread. Compared with wheat, rye possesses the same water content, a slightly lower protein and fat content, a slightly higher content of nitrogen-free extract (carbohydrates), about the same fiber content, a slightly higher mineral content, and about the same vitamin content. In digestible nutrients, however, rye is slightly inferior to wheat. On the other hand, the net energy value of rye, measured in terms of calories, is practically the same as that of wheat. A common observation is that a given quantity of rye bread satisfies a man's hunger for a longer period than the

same quantity of wheat bread. This can be explained no doubt by the larger production of heat in the longer period required to digest rye bread.

Consumers Prefer Wheat Bread

In all countries where rye bread is a staple item in the diet, consumers invariably manifest a distinct preference for bread made of wheat over that made of rye flour. Included among the factors accounting for the preference is the fact that, in addition to smaller volume and coarser texture, rye bread possesses a strong taste which becomes tiresome to consumers who have to eat large quantities of it regularly. Rye flour does not lend itself to as many variations in the baking technique as wheat flour, and bread made from it requires more chewing than wheat bread. Considerations such as these help to explain why in most bread-eating countries rye has over the years given way to wheat as a bread-making grain, especially among urban consumers.

Rye flour has a characteristic odor and taste, and these extend into the baked products. In fact, the taste and odor are so penetrating as to be obvious even in bread made of wheat flour containing no more than 5 percent of rye flour. In countries where the consumption of rye bread is large, many urban consumers find the strong flavor of ordinary rye bread rather monotonous and continue to consume it in large quantities only because no other bread is available to them at the price they are willing or able to pay. In countries consuming only relatively small amounts of rye bread, such as the United States and the United Kingdom, however, there usually is a limited demand for bread with the characteristic rye flavor because of an urge for variety or a desire for a different type of bread to be used on special occasions or for a change.

Rye Cheaper Than Wheat

Rye is a cheaper grain than wheat largely because a given quantity of rye at the same extraction ratio yields a smaller quantity of relatively high-priced flour and a larger quantity of low-priced offals. This is due mainly to differences in the shape of wheat and rye kernels and to the thicker skin of the rye kernel. With the flour always much more valuable than the bran, rye is naturally a lower priced grain because it yields less high-priced flour than wheat. In countries with a large consumption of rye bread, it is cheaper than wheat bread even when it is made from flour of a lower extraction ratio than that used for wheat flour. It is only in countries where relatively little rye bread is consumed that its price is as high, and sometimes higher, as a loaf of wheat bread of the same weight.

Machinery is employed in some of Poland's rye fields.

Where large quantities of rye bread continue to be consumed regularly, the principal reason is cheapness rather than consumer preference. This is especially true in countries with moderate or relatively low standards of living where wheat must be brought in from a distance and where marketing costs and/or governmental measures tend to increase the usual spread between the prices of wheat and rye bread. In such countries, wheat bread is more or less a luxury, and its consumption is confined to the wealthier classes or to special occasions, such as feast days, anniversaries, and national holidays. One of the major ambitions of many people in such countries is to attain an economic status at which they can afford to eat wheat bread three times a day. Rye is therefore frequently referred to as "the bread grain of poverty."

World's Consumption Declining

While rye was at one time the principal bread grain of rural people and industrial workers in all countries of Europe, and even in New England and other North American areas in the colonial era, its use for bread has been declining in favor of wheat. Being too expensive for large-scale consumption in many countries, the use of wheat for bread, rather than rye, came quite early to be regarded as a mark of superior social and economic status. The end of the French Revolution, however, started an upswing in the consumption of wheat bread in Europe. This trend was further expedited by World War I, which ironed out much of what remained of the distinction on the Continent between the so-called "working" and "better classes."

Officials of the United States Government inspect a stand of rye in the Soviet Union.

The revulsion against rye bread in Europe was especially noticeable after the end of the War of 1914–18. Because of short supplies of wheat and rye during those war years, European breads were "diluted" with barley, corn, oats, potatoes, and even the pulp of fodder roots. Such breads were unpalatable, moist and soggy, highly acid, prone to decompose quickly, and low in protein and nutritive value. Other factors contributing to the declining consumption of rye bread over the years were increases in wages, opening up of wheat-producing areas in non-European countries, improvements in, and cheapening of, transportation, progress in the breeding of better and higher yielding varieties of wheat, and the invention of methods of producing unlimited quantities of cheap synthetic nitrogen.

The decline in the consumption of rye bread is more or less confirmed by rough estimates of changes in the world's population and production of wheat and rye over a long period of years. The number of people in the world increased from roughly 1.6 billion at the beginning of the twentieth century to approximately 2.2 billion in 1938. In the same period, the world's production of rye declined from an estimated 1.8 billion (1900–04 average) to 1.7 billion bushels (1935–39 average), whereas the world's wheat crop increased from an estimated 3.5 to 6.0 billion bushels. Thus, while world population increased by roughly 38 percent, the world wheat crop increased by approximately 71 percent, but that of rye declined by roughly 6 percent.

The only areas in which rye bread still plays an important role as a foodstuff are those where enough wheat to satisfy local needs cannot be produced at all, or can be produced only at a very high cost. In such countries, rye bread is the predominating type among the poorer classes of people and wheat bread the predominating type among the more well-to-do. At the present time, heavy consumption of rye bread is confined mainly to a relatively limited region, comprising a large part of Germany, Czechoslovakia, Austria, the Scandinavian countries, Finland, the former Baltic States of Latvia, Lithuania, and Estonia, Poland, and northern Russia. And even in those countries, the trend is toward a larger consumption of wheat bread, or at least bread containing increasing proportions of wheat flour. Indeed, in Denmark, Norway, Sweden, Czechoslovakia, and Austria, the 1934–38 average per capita consumption of wheat flour was already higher than that of rye flour.

Nonfood Uses of Rye

While the major use of rye always has been for bread making, substantial quantities are used for feeding livestock in European countries. But even in Europe far smaller quantities of rye are fed than of oats, corn, and barley. In general, the taste of rye is not relished by livestock, and it must be fed with considerable care, since it tends to cause digestive troubles when constituting more than half the livestock grain ration. Germany, Poland, and Czechoslovakia together account for more than 60 percent of all the rye used for feed in continental Europe, Germany alone accounting for about 35 percent of the total. The quantities used for industrial purposes, principally rye whiskey, are small in all countries.

Climatic and Soil Requirements

With rye bread universally recognized as inferior to wheat bread in palatability and with consumers everywhere as a rule preferring wheat bread, with the world's livestock industries generally showing a distinct preference for corn, oats, and barley for feeding purposes, and with rye a naturally lower priced grain than wheat, the question arises as to why farmers continue to grow it, especially in such quantities as to make it one of the major food crops of the world. Although an oversimplification, the answer is that in the large rye-producing and rye-consuming areas of the world no other entirely satisfactory bread-making cereal can be grown that will consistently yield as much human food per acre as rye at such a low cost. Were it not for the possibility of producing large quantities of rye in those areas, a large region of the earth, which now sustains many millions of human beings, would probably be very thinly populated.

Winter hardiness, or ability to survive severe winters with a minimum of loss, is one of the outstanding

A Polish family gathers the rye crop.

characteristics of rye—the one that makes this grain a blessing to people living in climates too cold for wheat production. In that it will withstand virtually all kinds of weather, except hot, rye is superior to all other grains. It is definitely a cool-climate crop, yields being sharply reduced in regions with mild winters and long hot summers. It can be sown with assurance of a good crop in the fall of the year in regions where winter temperatures frequently fall as low as 40° F. below zero, and where the mean winter temperature is about zero. In Europe, winter-rye production extends north of the Arctic Circle to the 67th parallel. Indeed, the regions where higher yielding winter rye does not thrive have so little need for grain of any kind that there is hardly any reason for growing the lower yielding spring rye, except in years when the winter-rye crop is likely to be a failure. As a result, winter rye always constitutes the bulk of the world's rye crop.

Rye is less exacting in its moisture requirements than wheat. The exact amount of moisture required for best results varies, of course, with the seasonal rate of evaporation, which, in turn, is influenced by prevailing temperature, humidity, and wind movement. In general, however, it tolerates excessive moisture better than wheat, endures deficient moisture just as well, and the newly planted grain makes less demand on subsoil moisture. A rank growth occurs with excessive moisture and a stunted growth with deficient moisture; but, under both conditions, the tendency to head is relatively pronounced. In terms of yield, the outturn is less affected by extremes of moisture than in the case of wheat, and the fluctuations are less marked. Rye needs a larger amount of water per weight unit of grain produced than any of the other grains; undoubtedly its ability to grow more rapidly at low temperatures increases its efficiency in using moisture. The average annual precipitation in the region of Europe where the world's rye crop is largely grown is moderate, ranging between 20 and 30 inches, but with most of it occurring in the summer months when it is most needed by the growing crop.

Rye is less demanding in soil requirements than any other important cereal. It grows well over a wide range of conditions with respect to soil moisture, although it is adversely affected by conditions of deficient drainage. It is able to withstand considerable degrees of acidity and alkalinity and removes less nitrogen from the soil per crop acre than any of the other important grains. It may be grown on the same land year after year with less marked decline in yield than would occur if wheat were thus grown. It does better than wheat on old and exhausted soils, and it succeeds on peaty soils and moors where wheat would fail. It can be grown on sandy and other relatively inferior soils without apparent impairment of grain quality. This tolerance for sandy soil helps to explain the widespread distribution of rye over northern Europe.

Finally, rye is far less subject to attack and damage from insect pests and diseases than wheat. As far as rye yields and production are concerned, such factors as rust, smut, scab, mildew, cinch bugs, the Hessian fly, the joint worm, and grasshoppers are of little economic significance, although they are greatly feared by growers of wheat. As a result, rye can be grown for bread in many parts of the world where the prevalence of such diseases and pests might make wheat an extremely hazardous crop. The only serious pest of rye is ergot, the parasitic fungus which also attacks wheat and other small grains, but control measures are now applied in most producing countries.

Geographic Distribution of Producing Areas

The combination of all these factors accounts for the relegation of rye production as a major agricultural enterprise to the marginal or poorer lands of the earth. It also explains why farmers in many parts of the world continue to grow rye despite its relatively low price, compared with wheat. One of the great virtues of rye is the fact that not only can it be grown wherever wheat is the predominant crop but also in large areas adjacent to the wheat-producing regions where wheat, for one reason or another, would be an extremely hazardous crop, or where it would not thrive at all. It has indeed been suggested that rye became a cultivated crop, because it was so hardy a weed-grass that it could not be exterminated and finally became the major bread-grain crop in some

areas. The potential rye belt of the world, therefore, is much larger than the potential wheat belt. However, relatively little rye is grown where soil and climatic conditions permit reasonable yields of wheat, except possibly as a cover crop or in areas where the use of land for rye offers some special advantage in crop rotations and efficient utilization of labor.

Indicative of its widespread geographical distribution, production records for rye are available for 40 countries ranging in location from Alaska, Canada, and Siberia in the Northern Hemisphere to Australia, New Zealand, and the Union of South Africa in the Southern Hemisphere. As shown in the chart on the back cover of this magazine, however, more than 95 percent of the world's production normally is on the continent of Europe, including Russia. This great rye-producing area extends from the North Sea across Europe and Asia, in a continuous belt, mainly between the 50th parallels, to the Sea of Okhotosk, but it is produced also as far south as Spain, Italy, Greece, and Turkey.

During the 5-year period 1935–39, the world's rye area averaged 101 million acres annually with an average annual production of 1.7 billion bushels. European countries, with Russia, accounted for slightly more than 93 percent of the acreage and 95 percent of the production. The remaining 5 percent of the world's crop is grown mainly in the United States, Argentina, and Canada.

By far the largest area of heavy concentration of rye production in the world is in Russia. That country, in the period referred to, accounted for more than 60 percent of the world's acreage and 51 percent of the production. The greater part of the Russian rye acreage is located in the so-called nonchernozem region of poor forest soils that are moderately, or strongly, leached; moderately to strongly acid in reaction; and low in humus content. These soils are unadapted for any other major grain, except oats. In most of this vast area also, the winters are generally too severe for winter wheat.

The second largest area of heavy concentration is in Poland, which, in 1935–39, accounted for more than 13 percent of the world's acreage and 16 percent of the production. As in the principal producing areas in Russia, the bulk of the Polish rye crop is grown where soil and climatic conditions are unfavorable to the production of wheat as a bread grain.

The third most important rye-producing area in the world is in Germany, which accounted for approximately 7 percent of the world's acreage and 12 percent of the production in the period under reference. In Germany, however, as in all other European countries, the better lands are used for wheat.

Rye is also an important crop in a number of other European countries, especially in Austria, Czechoslovakia, Denmark, Finland, France, Hungary, the Netherlands, and Sweden. In those, as in the other European rye-producing countries, the acreage devoted to rye is determined largely by soil and climatic conditions, and especially by the extent to which sufficient quantities of wheat can be grown at a reasonable cost, as well as by requirements of the prevailing systems of crop rotation. Wheat is planted by preference wherever possible. But where prospects for wheat are poor, rye, oats, and barley are planted in accordance with customary crop-rotation practices.

Virtually all European countries produce wheat as well as rye, but very few of them produce enough wheat to meet their requirements. In some of them, considerable attention has been devoted to expanding wheat production at the expense of rye by the adoption of intensive methods of cultivation and by attempts at developing varieties that will give reasonable yields under existing climatic and soil conditions. Substantial progress along those lines has been made in several countries, but for vast areas of northern Europe, with their poor soils and severe winters, rye still remains the surer and the cheaper bread grain.

In brief, the continued importance of rye in the agriculture of north central and northwestern Europe

A harvest scene in Russia.

is explained by the fact that it provides a relatively low priced and excellent bread grain to offset whatever deficits may exist in the available supplies of the more expensive locally produced or imported wheat. The demand for a cheap feedstuff in the densely populated countries of Europe, which are climatically unsuitable for corn, is also a factor. For Europe, exclusive of Russia, however, the rye acreage has shown a definitely downward trend. This is evidenced by the fact that the average area devoted to the crop in all Europe, including Russia, during the 5-year period 1935–39 was 94 million acres, of which 61 million acres were in Russia. The average for 1910–14 was 107 million, of which 62 million were in Russia. Thus, while the acreage in Russia remained fairly stable, that of the rest of Europe declined by almost 27 percent from 1910–14 to 1935–39.

Non-European Rye Production Increasing

While rye acreage and production have been declining in Europe, exclusive of Russia, the crop has made substantial progress in the several non-European producing countries for which crop statistics are available. But even with this upward trend in production, the total rye crop in such non-European countries for the 5-year period 1935–39 averaged only 79 million bushels from approximately 7 million acres, compared with 40 million bushels from approximately 3 million acres during 1910–14. In order of importance as producers during 1935–39, the countries included in these non-European totals are the United States, Turkey, Argentina, Canada, and the Union of South Africa. The United States crop averaged 45 million bushels from 2 million acres. Just as in Europe, the production of rye in these non-European countries is relegated mainly to areas that are unsuitable for the production of winter wheat because of soil and climatic factors.

Rye in International Trade

Unlike wheat, which enters international trade in large quantities, the movement of rye in trade between nations is relatively small, being limited chiefly to the quantities needed to cover occasional deficits in countries which are themselves large producers. In fact, international trade in rye is much smaller than that of any other grain, except oats, and even oats frequently will move into export channels in slightly larger quantity than rye. The ranking of the grains as far as the usual tonnage in international trade is concerned is wheat, corn, rice, barley, and oats, or rye.

International trade in rye reached its peak at the beginning of the present century. Shortly after the turn of the century world exports of rye were averaging 117 million bushels (1909–10 to 1913–14) bushels annually. Since that time they have steadily declined. The average for the 4 years ended with 1938–39 was only 36 million bushels. World exports of rye during these years were only a small part of world production. In the 1909–13 period (year beginning July 1), they represented 11 percent of production and during 1925–29 and 1930–34, 4 percent. During the last 4 years preceding the outbreak of World War II, world exports represented only 2 percent of production.

Rye, therefore, is very much of a stay-at-home crop. Since most of it is produced and consumed in Europe, international trade in rye is naturally confined largely to that continent. Many European countries frequently import and export rye at the same time, either importing high-quality rye for bread making and exporting lower quality grain for feed, or importing feed rye and exporting food rye. Normally, however, Russia is by far the leading European exporter followed by Poland and the Danube Basin. The markets for the export surpluses are entirely within Europe itself, mainly Germany, the Scandinavian countries, Finland, Czechoslovakia, Austria, the Netherlands, and Belgium.

Outside Europe, only three countries are interested in exporting rye. These are the United States, Canada, and Argentina, which first became interested in producing rye for the export market after the end of World War I, when European countries were faced with a critical shortage of bread grain because of war devastation, poor crops, and the disappearance of Russia as an important source of supply. Rye exports from these three countries reached a peak during the 5-year period 1925–26 to 1929–30, together totaling 25 million bushels, more than half of which originated in the United States. Since then, such exports have declined drastically, averaging annually less than 2 million bushels each from the United States and Canada and slightly more than 3 million bushels from Argentina during the 4 years ended with 1938–39. The principal factors in the declining importance of rye exports from non-European countries during the 1930's was the recovery in European agricultural production and the adoption of trade barriers; the resumption of exports from Russia, supplemented by exports from Poland; and the fact that prices quoted on European-grown rye were generally lower than those on rye from overseas sources of supply.

Training Problems at Collaborative Agricultural Stations

by **ELLIS CLOUGH**

Efficiency in agricultural production and distribution is basic to the security and advancement of most peoples of the world. Attainment of such efficiency is a major objective of governments working toward national and world recovery and stability. More than half the world's population is occupied in agricultural production and distribution; yet the total available supply of food and other agricultural products does not meet world needs. Some predominantly agricultural peoples fall short of satisfying their own basic requirements. Uneconomic systems of land use and limitations of climate, soils, and market facilities are contributing factors. Dislocations caused by war are not fully corrected. A fundamental and persisting cause, however, is that great masses of agricultural workers do not possess the scientific knowledge and practices needed to make their resources yield greatest returns. Peoples and their governments are developing long-range cooperative programs in efforts to correct this condition as a major approach to national, regional, and world-wide recovery and stability; they are appraising, mobilizing, and sharing their resources of agricultural science.[1]

The United States has much to give and much to gain in these undertakings. Much of our own agricultural technology is applicable to other areas of the world. Many of these areas are actual or potential producers of agricultural and other strategic commodities needed by the United States. The use of scientific knowledge thus shared is increased by its wider application. It is transferred, not in ships and boxcars, but "through the minds of men." Deeper understanding and friendships between peoples and governments result from this interchange.

The results of such technical collaboration between the United States and other countries in this hemisphere demonstrate the effectiveness of this approach. The Congress[2] has recently broadened its original authorization to enable similar cooperation in other parts of the world. Under formal agreement, Department of Agriculture scientists are temporarily assigned to collaborate in research, demonstration, and extension activities at an agricultural station provided and maintained by the cooperating country.[3] Three fundamental principles provide the basis for such cooperation:

> First, cooperation should be in complementary fields of agricultural enterprise, and of such nature as to enable each country to increase its productive and distributive efficiency so that there may be less disparity between countries in their total efficiencies. Secondly, an increase in the efficiency of production and distribution can best be achieved by the maximum re-use of technical experience through the transfer of applicable scientific knowledge and skill from places where they are most highly developed to areas where they might effectively be applied. Cooperation among countries, therefore, should be of such a nature as to facilitate the ready transfer and adaptation of such experience. Thirdly, cooperation should be founded upon selected self-interests of the nations concerned, designed to advance these interests and thus merit the continuing support of the peoples and their governments.[4]

Collaborative agricultural-station programs have been established in the following Western Hemisphere countries: Bolivia, Ecuador, El Salvador, Guatemala, Nicaragua, and Peru. Cooperative projects of smaller scope are being conducted in Cuba and Costa Rica. The peoples and economies of these countries are predominantly rural and agricultural. The collaborative work is focused mainly on such complementary and strategic commodities as coffee, cacao, rubber, quinine, rotenone, pyrethrum, hard fibers, certain vegetable oils, and mahogany and other needed woods.

Systems of land use and other institutional factors in these countries have tended to retard the development of their own agricultural science and technical services. Their agricultural enterprises and economies have offered relatively few challenging career opportunities; few young persons have been stimulated to secure basic and specialized training in agricultural sciences. As a consequence, agricultural schools and colleges and research programs have developed slowly. Complete technical services to farmers and

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[1] HILL, C. REED. MOBILIZING OUR SCIENCE FOR WORLD-WIDE COOPERATION. Foreign Agr. 12:123–125, illus. 1948.

[2] Public, No. 402, 80th Cong.; see EWING, QUINCY. WIDER HORIZONS FOR AGRICULTURAL COLLABORATION. Foreign Agr. 12:76–79, illus. 1948.

[3] HEPLER, JOHN V. AGRICULTURAL COLLABORATION WITH FOREIGN COUNTRIES. Foreign Agr. 12:14–17, illus. 1948.

[4] MOORE, ROSS E. AGRICULTURAL COOPERATION WITH THE AMERICAN REPUBLICS. U. S. Dept. State Bul. 17:613–617, 650. 1947.

other groups cannot be extended until supporting knowledge and techniques are verified.

Development of Staff—A Major Problem and Objective

In view of the conditions cited above, the development of a competent staff of nationals is a major problem. It is also a major objective—consistent with the general aim of the over-all program of Scientific and Cultural Cooperation—namely, the exchange of information, knowledge, and skills. Technicians of the cooperating country often do not possess the basic and specialized competence required by the station projects. Individual United States scientists are assigned to the station for temporary periods only; after a specialist has established a sound program, including a good staff, he is replaced by a specialist in another field and transferred to another station or project. Thus the training of nationals for the staff is a natural and logical step in the total station program.

The kinds and complexity of station projects reveal the competencies needed in members of the staff. The following examples are taken from the program of the Instituto Agropecuario Nacional in Guatemala: Development of a soil map for Guatemala; development of soil-analysis service for farmers; research on methods of analysis of cinchona bark (for quinine and other alkaloids); effect of size of cutting on time, percentage, and extent of rooting of cinchona cuttings; the effect of various spacing and pruning treatments on the growth and yield of coffee; introduction and propagation of improved varieties of fruit trees; studies on avocado grafting; introduction and testing of forage grasses; introduction and trials of grain sorghum; and selection of native Barroso cattle for milk production and stable breed characteristics. To design and conduct such research, to reduce findings to appropriate farm practices, and to secure the adoption of these practices by farmers requires scientific and technical training and experience of a high order. Such competence is attained only through years of systematic training in the basic and applied sciences and in specialized fields; appropriate laboratory and field practice is essential.

Peruvian colonists clearing lands adapted to the production of high-value tree crops, such as cinchona and rubber. The cooperative station at Tingo María is developing superior plant strains and appropriate production practices.

As noted in an earlier paragraph, many of the cooperating countries do not provide training of this character. Only to a limited degree can training in the station overcome the deficiency. Further training must be secured elsewhere, and for the immediate future this usually must be obtained outside the country. Thus, the development of an associate technician presents training problems on three different levels or stages—preparation before he joins the staff, in-service training at the station, and further training on leave from the station.

Local Training

As previously mentioned, land use and other institutional factors in many of the cooperating countries have retarded the development of indigenous agricultural science and of career opportunities in professional and technical agriculture. Of the eight countries involved, only three have a college of agriculture where the basic work offered is considered comparable to that provided in some State colleges in the United States; four countries maintain a school of agriculture; and one country does not at present provide systematic education in agriculture at any level. One of the countries has a college and schools of agriculture as well. The offerings of some of the schools of agriculture are similar to those of our own vocational high schools and practical schools of agriculture.

The college curricula are 4 or 5 years in length, leading to the degree of Ingeniero Agrónomo. Little or no opportunity for specialization in various fields is provided. Significant proportions of the instructional staff have had advanced training in their specialties in universities abroad. Teaching facilities and materials are reasonably adequate, although much of the recent development in the applied sciences is not available in journals and books in the language of the country. Teaching methods tend to be academic in character. Laboratory and field-practice facilities are sometimes lacking; when available, their use is not always integrated with the

theoretical studies. However, in the countries having colleges of agriculture, basic preparation for work in the cooperative stations is fairly adequate. Usually further study is necessary to attain the specialization required in some of the stations' research projects.

The training offered in the more common and elementary "schools of agriculture" is not of the kind and level needed to prepare technicians to assume important responsibilities in designing and conducting agricultural research and other scientific-technical projects and services. The courses of study in these institutions are usually 4 or 5 years in length; the title granted on completion is that of Perito Agrícola ("agricultural inspector" or "expert") or a similar designation. These schools are usually financed and broadly administered by a Ministry of Agriculture or by an association of large coffee-fruit-sugar and livestock producers. Top-ranking graduates commonly find employment in the ministry's clerical divisions and in its extensive regulatory activities over the country. Others enter positions in the producers' associations or in large private farming enterprises, eventually to become foremen and administrators. Many return to assist in managing their own family enterprises. Beginning salaries may range from $50 to an occasional $100 per month.

The boys enroll at ages 14–16, after they have completed their 6-year elementary schooling and perhaps 1 or 2 years of secondary education. Their preliminary schooling is academic-classical in character and usually includes elementary general science, biology, and botany. The 5-year curriculum of the National School of Agriculture in Guatemala is representative of the better schools of this type:

First Year: Spanish Grammar and Composition, English, Practical Arithmetic, Botany, Horticulture and Fruit Growing.

Second Year: English, Algebra and Geometry, General Chemistry, Entomology, Animal Husbandry.

Third Year: Physics, Agricultural Chemistry, Plant Pathology, Agronomy, Animal Husbandry.

Fourth Year: Agronomy, Soil Conservation, Agricultural Arithmetic, Animal Diseases and Parasites, Agricultural Accounting.

Fifth Year: Animal Diseases and Parasites, Dairying, Plant Pathology, Microbiology, Agricultural Administration, Farm Buildings.

Instructional materials are a special problem in these schools as in the colleges mentioned above.

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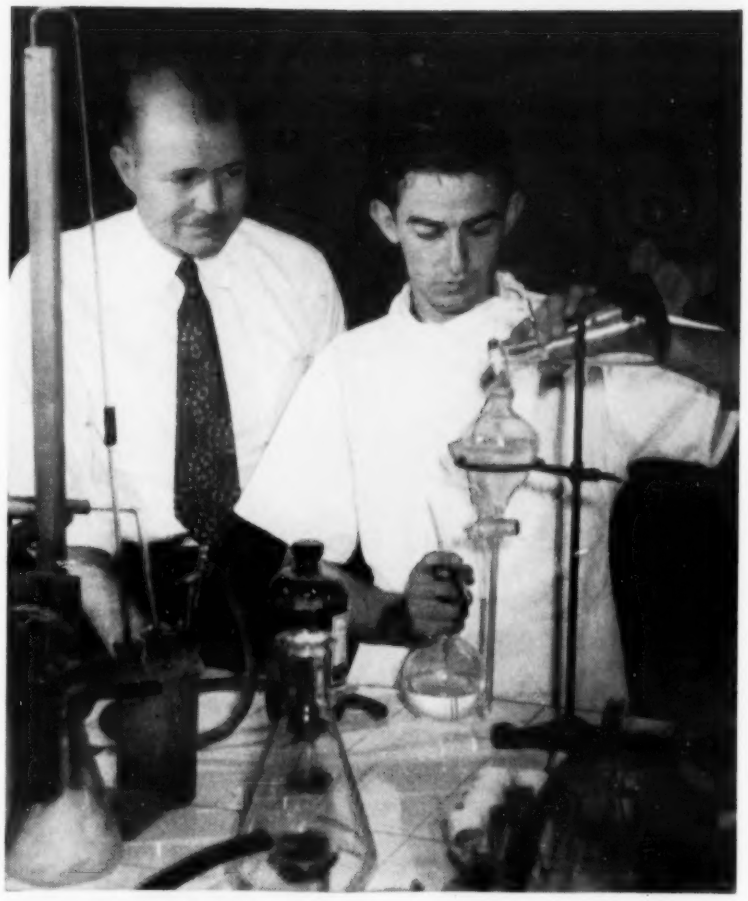

A Guatemalan (right) learning laboratory techniques under a United States biochemist in the cooperative station.

Existing Spanish-language textbooks and reference materials which present the applied sciences of agriculture appropriately for such students and their teachers are limited in number. Mere translations of such material from the English or other language do not solve the problem. The science and practices needed for training-study purposes should be as indigenous as possible. This is one of the primary reasons why academic teaching procedures and study habits persist in these and other countries. Limited laboratory facilities in the sciences is another contributing factor. The school farm usually presents good opportunities for field demonstrations and practical experience in agronomy, agricultural engineering, and animal husbandry, and some instructors and students make good use of these facilities. Lack of proficiency in laboratory techniques and field and livestock practices is, however, one of the most serious limitations of students who join the station staff.

The regular course provides little or no opportunity for specialization or for advanced training after its completion. In some of the schools students are required to devote several months of their last year to securing practical and specialized experience outside the school. The cooperative stations have accepted and provided special training for many of the more promising students. A significant number of these

A Salvadoran technician and a United States specialist making test-plot observations at San Andrés.

students have eventually been added to the station staff.

Not all the school instructors are specialists in the subjects taught. The level of salaries usually paid does not encourage teachers to secure further education. Some teach or work part time in other positions in order to supplement their regular earnings. Part-time or vacation work at the cooperative station offers possibilities for their further experience and training.

Some of the countries without a college of agriculture are now giving serious consideration to establishing one as a part of their national university. Under such a plan, agricultural students could secure their basic science training in courses already being offered. However, finding fully qualified persons to organize and teach the agricultural sciences and related subjects would be a difficult problem in some countries. The assignment of United States specialists at the station for part-time teaching has been considered, and the use of "visiting professors" is helpful. Another approach to the problem is through the selection of promising young nationals as potential teachers and then giving them assistance in securing basic and specialized training outside the country in the needed subject-matter fields. In view of the stations' urgent need for better trained nationals, this approach deserves special consideration. In order to develop agricultural science and practice appropriate for the new curricula, it is obviously important that research and technical services be expanded as early as possible.

In-Service Training at the Station

The cooperative stations are directed and administered jointly by representatives of the two governments involved. The various departments of the station, however, are usually headed by a United States scientist. Within the limits of the funds provided by the other country, the ablest nationals available are employed and assigned to these department heads as associate technicians. Other assistants and workers make up the rest of the departmental staff. These vary widely in number, from perhaps only 1 or 2 to 10 or more. Salaries paid to nationals compare favorably, and sometimes slightly exceed, salaries paid elsewhere in the country for the same level of ability.

A few of the associate technicians bring excellent backgrounds of training and experience to the station program. They have secured all the agricultural training available in their country, and a significant proportion have obtained specialized training and advanced degrees from colleges and universities in the United States. Generally speaking, the assistant technicians have also completed all the training provided in their country. Frequently, however, the competencies possessed by the nationals do not fully meet the requirements of specific projects in the program. This relatively low degree of competency limits research to a level that is below the requirements for a program in the further development of complementary and strategic crops. Thus the training of the associate and assistant technicians becomes a natural and essential responsibility of the United States scientists.

The everyday relationships between our men and the technicians provide frequent opportunities and favorable conditions for training. The needed knowledge and skills can be exchanged in natural situations, with the essential materials readily at hand, in an atmosphere familiar to the learner; there is opportunity for assignment of appropriate responsibility and for repeated use and practice of the knowledge and techniques learned. Consistent with the broad objectives of the over-all program, the learner has opportunity to become a teacher and pass on to other nationals appropriate parts of his learning; the unskilled laborer in the laboratory or field eventually may benefit in this process. The cooperative planning of projects provides good opportunities for systematizing the training to be carried on within a proj-

ect; a listing of techniques to be employed in the project provides a basis for a joint appraisal of the knowledge and skills already possessed or to be learned.

Such analysis enables assignment of definite responsibilities to the trainee and facilitates the selection and timing of specific readings and study. This procedure also provides a simple method for checking on performance. Small group and staff conferences and systematic seminars for nationals in all departments of the station are strongly recommended. Plans are being made for the development of strategic subject matter for such seminars, including visual material. Most of the stations have accumulated extensive libraries of technical books, journals, bulletins, and other materials. Unfortunately few of these are in the Spanish language. A systematic program of English study is strongly recommended; many technicians are developing facility in languages on their own initiative.

Several factors limit the training that can be provided by the station. Some of these are: Lack of background preparation of nationals in basic subject-matter fields; lack of instructional facilities, for example, certain laboratory apparatus, in the station for formal education in some basic subjects; lack of established techniques applicable to the conditions prevailing in the cooperating country; language handicap on the part of both the nationals and the United States specialists; pressure on staff for immediate research results; and the assignment of some technicians to substations quite a distance from the United States specialists' headquarters.

Training on Leave from Station

To supplement the formal and in-service training previously secured, selected nationals are granted leave from the station, frequently on full or part salary, to secure additional training outside the country. Most of them are sent to the United States, but a few have gone to the Inter-American Institute of Agricultural Sciences at Turrialba, Costa Rica. This relatively new institution, established and largely financed by the Pan American Union, is developing rapidly as a research and demonstration center in tropical agriculture. A few others have attended the Escuela Agrícola Panamericana, established by the United Fruit Co. in Zamorana, Honduras. Work there is intensely practical and especially valuable for younger workers who have had no opportunity for agricultural education in their own country.

Periods of training on leave vary from a few months to 4 years in some cases. Many of those coming to

A Salvadoran technician discusses cooperative research in coffee-tree nutrition with a plant pathologist and a horticulturist from the United States. He has recently begun undergraduate training in this country on a 4-year scholarship granted by the Ministry of Agriculture of El Salvador.

the United States are given special training within Department of Agriculture bureaus and at their field stations and projects. Others are placed in selected State agricultural colleges and experiment stations for formal study combined with practical laboratory and field experience. Individual training programs are cooperatively planned, directed, and financed. The Office of Foreign Agricultural Relations furnishes two specialists in agricultural education and training who provide professional and coordinating services to the several agencies involved—the cooperative stations, individual trainees, bureaus of the Department, colleges, and others. One of these specialists works with the cooperative stations in the field on all problems and activities involved in developing the staff; the other coordinates the work in the United States from his office in Washington. Specialists in various bureaus of the Department arrange and supervise the training provided within the bureaus and assist in placing the trainees in State colleges and experiment stations.

Funds needed for trainees' expenses in the United States come from several sources, including the cooperative station and/or Ministry of Agriculture, the trainees' own resources, training grants awarded by the Department of Agriculture, and tuition scholarships granted by colleges. Funds for Department grants are allocated by the Interdepartmental Committee on Scientific and Cultural Cooperation. These grants may provide any part or all of a trainee's travel and his maintenance while in the United States. The Department bureaus provide facilities for training without charge.

Principal Field Crops of Japan

Japan is a small country—about the size of California—but it has a population of nearly 75 million people. In fact, it is often referred to as a country of "many people on little land."

by **WARREN H. LEONARD**

Agriculture is the most important single industry in Japan,[1] because about 50 percent of the national industrial capital is invested in it, and because about 47 percent of the population is engaged in it for a livelihood. It is the only industry in Japan that, except for a shortage of fertilizers, came through World War II (1941–45) without serious impairment.

Of the crops grown, five—rice, barley, wheat, sweetpotatoes, and potatoes—generally supply 85 to 90 percent of the calories from indigenous sources in the Japanese diet. From the standpoint of acreage and production, these five are also the principal field crops (table 1).

Rice dominates the entire agricultural economy. In 1945 this crop occupied approximately 53 percent of the total cultivated area and about 42 percent of the total crop area. About 96 percent of the crop is grown on irrigated lowlands. This cereal is better adapted than any other to the long growing season, high temperature, and heavy rainfall characteristic of the larger part of Japan.

Because they require temperate-climate conditions, barley and wheat are grown in the winter and spring months in central and southwestern Japan. Sweetpotatoes are a warm-season crop limited largely to the region south of 38° N. latitude, whereas potatoes—so-called white or Irish—are a cool-season crop grown extensively in more northern latitudes.

Rice Culture Is Expanding

There was a gradual increase in the cultivated area, production, and yield per unit area of rice during the 60 years from 1883 to 1942. Area increased by 22 percent, production by 88, and yields per unit area by 54 percent. These increases are attributed to the use of large quantities of fertilizers and to improved varieties. Rice occupied 7,575,600 acres annually and returned 510,355,200 bushels of rough rice, on an average, during 1941–45. (See table 1.)

TABLE 1.—*Area and production of the major food crops in Japan for the 5-year period, 1941–45*

Crop	Average 1941–45		
	Acreage	Production	Yield per acre
	1,000 acres	*1,000 bushels*	*Bushels*
Rice, rough	7,575.6	510,355.2	67.4
Wheat	1,992.0	46,505.8	23.3
Naked barley	1,202.3	31,113.1	25.9
Covered barley	964.7	31,345.5	32.5
Sweetpotatoes	861.3	173,797.6	201.8
Potatoes (white or Irish)	478.6	73,200.6	152.9

SWANSON, C. L. W. FERTILIZERS AND FOOD PRODUCTION IN JAPAN. Fertilizer Rev. 22 (55): 7–11. 1947.

All Japanese rice is of the short-grained type. It is classified in Japan proper as paddy and upland, or common (nonglutinous) and glutinous. Most of the production is of paddy rice of the common type.

Paddy rice is cultivated in paddy fields where it is irrigated throughout the growing period, whereas upland rice is able to complete its growth in the field without irrigation, as is true of wheat. Paddy rice occupied about 95.4 percent of the rice area, on an average, during 1938–42 and accounted for about 97.8 percent of the average annual production.

Failures of the paddy-rice crop in the cool northern districts of Hokkaido and Tohoku are generally caused by low temperatures, especially when they occur in July or August, but one of the difficult problems in rice production in the warm districts of southwestern Japan is the serious outbreaks of insect pests.

Cultivation of upland rice is largely confined to the Kanto and Kyushu districts because of (1) the light soil derived from volcanic ashes, (2) a deep surface soil, and (3) frequent summer showers. Upland rice is often damaged by cool weather in the districts north of Kanto, or by summer drought. The yield of upland rice is only about 60 percent of that of paddy rice in Kyushu.

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[1] For a general description of Japanese agriculture, reference is made to: LADEJINSKY, W. I. AGRICULTURE IN JAPAN: PREWAR. Foreign Agr. 9: 130–142, illus. 1945.

Paddy Rice Is Usually Transplanted

Paddy rice in Japan is almost always grown by the transplanting method, [2] in which the seedling rice plants are started in nursery beds and later transplanted into paddy fields. The principal reason for the practice is to permit a fall-sown wheat or barley crop to mature before it is necessary to transplant rice. This permits two cereal crops on the land per year, whereas only one would be possible in direct seeding of rice.

The rectangular nursery seedbed is carefully prepared with a hoe (kuwa). The beds average 4 feet in width, with a 1-foot path between them. The rice seed is usually planted from April 1 in northern Honshu to as late as May 15 in central Honshu. About 30 days are generally required for seedlings to attain a size suitable for transplanting. The area of the nursery bed is about 3 to 4 percent of the paddy-field area.

Paddy fields are prepared by plowing, irrigating, making boundry footpaths (bunds or levees), and leveling (puddling). The field is either hand-spaded or plowed with animal power. On land where winter crops precede rice, the fields are plowed after the harvest of the winter crops. After the clods have been broken with a hoe, the land is stirred, irrigated, and leveled (puddled).

Paddy fields are heavily fertilized. Chinese vetch or soybeans are often plowed under at the rate of 3 to 7 tons per acre after the material has been allowed to dry for 2 or 3 days. The fertilizer recommendations for the rice crop in Japan are as follows: Nitrogen (N), 58 to 135 pounds; phosphoric acid (P_2O_5), 35 to 90 pounds; and potash (K_2O), 50 to 100 pounds per acre. Barnyard manures are usually applied before irrigation and the other fertilizers after leveling. Nitrogenous fertilizers are applied twice—about half when the paddy field is being prepared and the balance just before jointing of the plants.

Rice plants are generally transplanted into the field in hills evenly spaced in only one direction. The rows are usually 8 to 12 inches apart, and the hills in the row are between 3 and 8 inches apart. Transplanting is usually done in June

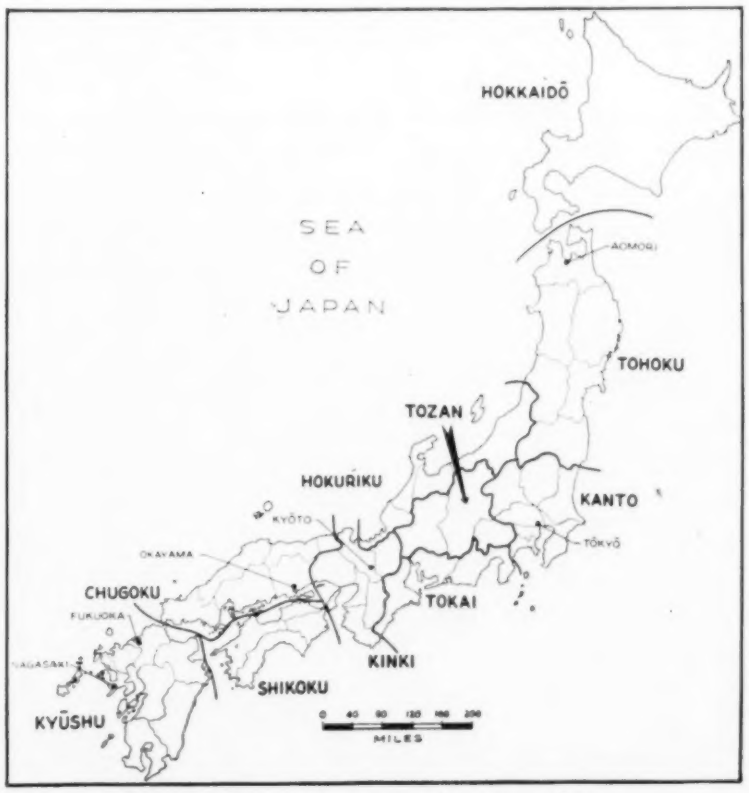
From 2.3 to 4.3 acre-feet of irrigation water are required for the entire growing season. The standard depth of irrigation water is 1 to 2 inches. The water must be rather deep immediately after transplanting to hold the seedlings erect, shallow during the tillering stage, and shallow to half-dry in midsummer. The fields are drained when the rice plants begin to ripen, that is, when the heads start to bend over.

One significant wartime development in rice culture was the growing of rice on the ridges where the wheat or barley had been grown. The ditches, or furrows, were flooded until the water came to within 3 inches of the rice plants. The practice was found to save both labor and fertilizer and to control the rice blast disease, because the plant was kept out of the water.

Direct seeding of rice in paddy fields is practiced in Hokkaido and sometimes in other places. The principal reasons for direct seeding are the short season and the lower labor requirement for farmers who have comparatively large fields per family. Direct seeding is done from May 15 to 25 at the rate of 9 to 13 pounds per acre. The Japanese claim that direct seeding requires a great deal more labor for weed control than does the transplanting method. When the weeds are controlled, the yields are about equal to those obtained by the transplanting method.

Upland Rice May be Interplanted

Upland rice may be interplanted in wheat or barley. If so, shallow furrows between the rows of standing grain are prepared, fertilizers added, and the seed sown. When upland rice is sown after wheat or barley has been harvested, rows are made by digging up the stubble. Land without a spring crop is spaded, or plowed, in April or May after which the field is harrowed and furrows are made for planting.



Map showing agricultural districts of Japan.

[2] LEONARD, WARREN H. RICE AS A CROP IN JAPAN. Jour. Amer. Soc. Agron. [In press.] 1948.

Threshing rice in Japan with the cylinder foot-power thresher.

Upland rice is usually seeded at the rate of 4.5 pounds per acre in drill rows, 22 to 24 inches apart, with seeds 3.5 to 5.0 inches apart in the row. In the Kanto district, sowing begins on bare fields about May 1, between wheat rows from May 15 to 31, or after the wheat harvest in early June. In the Kyushu district, upland rice is generally sown in late May or early June.

Fertilizers are normally applied at the rate of about 80 pounds of nitrogen, 67 of phosphoric acid, and 62 of potash, per acre. The 2 to 3 tons of fertilizer applied per acre include barnyard manure, ammonium sulfate, soybean cake, superphosphate, and wood ashes.

Two or three cultivations and weedings are made between June 15 and August 1. Sometimes thinning is done at the time of the first cultivation, and the excess seedlings are transplanted to places with poor stands.

Rice is harvested by cutting the plants near the soil surface with hand sickles. In low-rainfall areas where the fields are dry, the plants are thinly spread on the ground, or stood in bundles, to dry. In other areas, the bundles are usually hung on racks to dry for about 20 days.

Dried bundles are shocked out of doors or carried indoors for threshing. Either manpower or motors may be used for threshing. Threshed rough rice is cleaned either by use of sieves or by a winnowing machine.

Threshed and cleaned grain is dried for 3 to 4 days on mats until the moisture content has been reduced to 13 or 14 percent. The hulls are removed after drying by passing the grain through a dehuller. Rough rice yields from 70 to 80 percent of brown rice by weight, or 50 to 60 percent by volume. Brown rice is marketed in rice-straw bags with a capacity of 132.3 pounds. It is commonly milled for use as food. The extraction rate for polished rice varies from 85 to 90 percent. During World War II and afterward, the Japanese used a so-called 70-percent polished rice. It is an undermilled product with about 30 percent of the outer-kernel layers retained. The extraction rate would be 95 to 96 percent.

The labor requirement for producing 1 acre of paddy rice is high when compared with American standards. Some data from Saitama Prefecture indicate that the labor requirement for the production of 49.6 bushels of brown, or 86.4 of paddy, rice on 1 acre of paddy land was 80 man-days and 10.9 horse-days.

Several diseases attack the rice crop. Probably the most serious is blast (*Piricularia oryzae*), which appears as spots on the leaves, neck or peduncle, and nodes of the plant. The panicles bear no grain when the spots appear in the shooting stage. Conditions that favor the disease are long-continued cloudy warm weather, excessive applications of nitrogenous fertilizer, thick stands, late planting, and cool irrigation water in the mountainous areas. The control measures used are: (1) Removal of affected plant material from the field, (2) treatment of seed with formalin or Uspulun, (3) repeated spraying of plants with bordeaux mixture, and (4) use of resistant varieties.

Among the most serious insect pests of rice in Japan is the two-brooded rice borer (*Chilo simplex*), which is widespread. The larvae survive the winter in the straw or stubble. They bore into the stem and cause it to die. The principal control measure is to catch the moths and collect the eggs. Many moths are attracted by insect lamps and killed. Farmers are encouraged to kill the eggs during the nursery period or to cut the stems that have changed color.

The three-brooded rice borer (*Schoenobius incertellus*) is observed only south of the isothermal line where the lowest winter temperature reaches 25.7° F. Outbreaks commonly occur in the districts of Kyushu, Shikoku, and in some parts of Chugoku. The first brood occurs in April or May, the second in August, and the third in September. The larvae bore into the stems, which either die or fail to ripen. Control measures are similar to those for the two-brooded rice borer, except that late transplanting enables farmers to avoid the first-brood stage.

Outbreaks of leafhoppers may occur several times in a year. When they suck plant nutrients from the stem, the result is poor growth or no grain production. Insects in nursery beds are controlled by floating a petroleum extract of pyrethrum over the water and brushing the insects down into it. Farmers use only

petroleum when paddy fields are infested. When the fields are dry, they spray petroleum emulsion or nicotine sulfate.

Barley Is Second Most Important Crop

Barley ranks second among the crop plants of Japan, 14 percent of the arable land being devoted to it.[3] About 60 percent of the crop is of naked barley and 40 percent, of covered. Approximately 2,167,000 acres represented the average yearly area devoted to the crop during 1941–45.

Most of the barley grown is of the spring type, but it is generally fall-seeded. Naked barley predominates in southwestern Japan, mostly in areas with an average January temperature of 37.4° F., or higher. Covered barley is grown most widely in central and northern Japan where the winter temperatures are lower.

Almost all the barley grown is of a common six-row variety (*Hordeum vulgare*), but varieties of *H. intermedium* and *H. distichon* are also grown. The short awns found in most commercially produced awned varieties are typical of Japan.

All the varieties produced in Japan show a wide variation in culm length; namely, short type, with culms about 20 inches long, and the tall type, with culms about 43 inches long. The tall or normal type is generally grown on upland fields in the colder regions north of the Kanto district. The short or semibrachytic type is grown on the highly fertile soils (paddy fields) in the warm regions of southwestern Japan. Varieties of this type are less likely to lodge on such soils than the taller barley.

Most of the barley in Japan is grown alternately with another crop in the same season. The fields vary in size from a few square yards to 0.25 acre, with occasional fields in Hokkaido of 2.5 acres, or more, in size. When barley follows rice on paddy land, the field is generally ridged so that the crop can be planted on top of the ridges. On upland fields it is a common practice to seed sweetpotatoes, soybeans, or upland rice between the rows of standing barlev before the grain is harvested.

For upland barley seeded in the fall, the rows are made 24 to 28 inches apart. The land is heavily fertilized under normal conditions. The crop is seeded from September 10 to December 10, or as soon as the land can be prepared after removal of the previous crop. The rate of seeding varies from 48 to 68 pounds per acre for covered barley and from 50 to 74 for naked barley.

Barley is often grown after rice on paddy fields. The land is thrown up into ridges 4 to 6 feet apart and from 2 or 3 to 16 inches in height in order to ensure drainage.

Most of the harvest occurs in June and is carried on with hand sickles. The grain is either laid in the

[3] LEONARD, WARREN H. BARLEY CULTURE IN JAPAN. Jour. Amer. Soc. Agron. 39 (8): 643–658. 1947.

Typical gardenlike fields in Japan.

swath for several days to dry, or it is tied in bundles and hung on wooden, or bamboo, frames to dry. Then the dried grain is threshed with small threshers, often foot-powered. The grain is usually separated from the chaff by winnowing. The cleaned grain is dried on straw mats to a moisture content of about 13 percent.

In order of their importance the most serious barley diseases in Japan are snow blight (*Typhula* spp., *Fusarium* spp., and *Pythium* spp.); stripe; yellow, stem, and leaf rusts; powdery mildew; scab; covered and loose smuts; foot rot (*Corticium gramineum*); and rosette.

Scab and covered smut are controlled by treating the seed with commercial organic-mercury compounds, such as Uspulun or Ceresan. A modified hot-water treatment has been used to rid the seed of loose smut. Barley plants are sprayed in the field with a lime-sulfur solution when outbreaks of yellow rust, leaf rust, powdery mildew, or scab occur. The plants are protected from snow-blight damage in areas of heavy snowfall by spraying with bordeaux mixture before the first snow comes.

About 75 percent of the naked barley and 64 percent of the covered barley were used for human food in 1942. Barley is pearled and cooked with ordinary boiled rice. It can be mixed with rice up to 50 percent without serious reduction in palatability of the rice. Utilization of barley for livestock feed is of minor importance.

Wheat Has Grown in Importance

From a position of relative unimportance, wheat in recent years has become one of the major crops in Japan. During 1941–45, production averaged 46,505,800 bushels per year from 1,992,000 acres, with an average yield per acre of 23.3 bushels. Both acreage and yields per unit area have been greatly improved within historical times. Based on 5-year averages for the periods 1878–82 and 1938–42, the areas in wheat have increased about 119 percent, yields about 140, and total production has expanded about 425 percent.

The larger yields per unit area have been attributed to a greater use of fertilizers and more productive varieties. The greatest area increase took place as a result of a 5-year plan to increase production, inaugurated by the Imperial Japanese Government in 1932 to make the country self-sufficient in this grain.

Wheat is grown in virtually all parts of Japan, but the principal areas of production are in Kyushu and central Honshu, especially on the Kanto Plain. In this general region, spring types are grown, but they

Sweetpotatoes spread out on mats to dry.

are seeded in the fall as in California. Much of the wheat grown in Hokkaido is also of spring type, but it is seeded in the spring. Elsewhere the predominant varieties are winter types seeded in the fall.

Approximately 66 percent of the wheat area is seeded to improved varieties produced during the past 30 years by the agricultural experiment stations. All wheat in Japan is soft or only semihard. The protein content averages 10 percent or less.

Cultural methods for wheat are similar to those ... barley. On wet, poorly drained soil the unive... practice seems to be to prepare beds of various widt... with furrows between, or to construct ridges on t... of which the wheat is seeded in single or double row... Nearly all wheat is seeded by hand. Quite often ... Kyushu the seed is broadcast in rows or bands 6 to ... inches wide, either lengthwise or crosswise of the beds, which are 3 to 5 feet wide. The seed is covered with a rake or similar implement.

On uplands where drainage is not a proble... neither beds nor ridges are used. Nevertheless, wh... is always seeded in rows and never broadcast. T... rows are generally 12 inches, or more, apart to perm... the seeding of another crop between the rows befo... the wheat is harvested.

The principal wheat diseases are scab, mosa... yellow rust, leaf rust, stem rust, mildew, bunt o... stinking smut, septoria, and loose smut. Scab is regarded as one of the most serious diseases in southwestern Japan. Disease-control measures are similar to those used for barley.

Probably about 75 percent of the wheat crop is milled into flour. The remainder is pearled and cooked with rice. The flour is often used for noodles.

The Sweetpotato Is the National Stand-by

For generations the sweetpotato has been the national stand-by in famines when August-September rains ruin the paddy fields. Production is most extensively developed in the Kanto district and southwestern Japan. It is also widely grown in Kyushu, where it forms a major item of the diet. The acreage devoted to sweetpotatoes during 1941–45 averaged 861,300 acres, which returned, on the average, 173,797,600 bushels. The 1945 acreage was increased to more than a million acres, largely because of the critical food shortage.

Sweetpotatoes are grown mainly on the upland soils of the so-called diluvial terrace formations and on volcanic-ash deposits. They are also grown in Kyushu on steep mountain terraces up to 1,000 or 1,200 feet in elevation. Yields on high mountain terraces average only about 60 percent of those on lower uplands because of the lower natural fertility of the soil. Annual rainfall is more than adequate for the crop wherever sweetpotatoes are grown.[4]

In contrast to American practice, Japanese farmers consistently use compost and manure directly under the sweetpotato ridge at rates of 3 to 5 tons per acre. Little other fertilizer was used in 1946, except variable amounts of plant ashes up to 800 or 1,000 pounds per acre. The ashes, or commercial fertilizer when available, are either mixed with, or spread in a band on top of, the compost, which is laid in furrows spaced 2.5 to 3.0 feet apart. The ridge is then made over this material without mixing the material with the soil. "Night soil" or commercial fertilizer is rarely used as a top dressing.

The varieties of sweetpotatoes eaten in Japan would be unacceptable for food in the United States, because they are virtually without carotene and many have unattractive flesh colors when cooked.

Sweetpotatoes are propagated in Japan (Kyushu and elsewhere) in hotbeds or cold frames—often made of bamboo and rice straw. Manure-heated hotbeds built on top of the soil were observed in Saitama Prefecture. The walls, about 2 feet high, were made of braided barley straw supported by a frame of bamboo stakes and poles held together by straw rope. The beds were 6 feet wide and of various lengths up to 24 feet. Manure and soil brought the bed surface about 16 inches above the level of the yard. Electric-heated hotbeds are also found. Some districts have hot springs as a cheap source of heat, the hot water being piped through the beds. In southern Kyushu no artificial heat is provided for beds made after April 1.

In southern Kyushu the plant beds are started about March 15, but elsewhere on the island, in early April. From 7 to 8 weeks are required for the plants to become large enough for transplanting.

Transplanting is begun in most of Kyushu as soon after May 15 as conditions permit. Since barley or wheat usually precedes sweetpotatoes, transplanting is started only after June 10 or 15, when the grain is harvested. In central Honshu, sweetpotatoes are often transplanted in with wheat and barley about 3 weeks before the grain is harvested. This usually occurs from May 20 to June 1. The plants are placed in rows 2 feet apart and about 1 foot apart in the row. The sweetpotatoes are set on ridges near the small grain plants which shade the potatoes until after the grain is harvested.

Field ridges on which sweetpotatoes are planted in Kyushu are normally 8 to 12 inches in height. Where drainage is poor, the ridges are 12 to 15 inches in height.

The Japanese recommend that sweetpotatoes be harvested before frost kills the leaves, because low temperatures before, or at, harvesttime impair the keeping quality of the crop. This means that the crop is largely harvested early in October in northern Kyushu, but it may be as late as November 20 in the southern part of the district. The vines are fed to livestock or dried and ground into flour for mixing with other food products for human consumption.

Storage of sweetpotatoes in Japan is a critical problem because of losses from spoilage. These losses from inadequate storage are less serious in the warmer parts of Kyushu than in the colder parts of the country. They run as high as 40 percent in some parts of Japan. In the colder areas, few roots other than seed stocks are stored much later than January 1. On the average, about a third of those stored for seed are lost by bedding time. Some of the better varieties can be stored in Kyushu in field pits, 2.5 to 3.0 feet deep, until the end of February.

Storage losses appear to be due to (1) failure to control black rot and (2) failure to cure the roots at the proper temperature and humidity before subjecting them to the satisfactory storage temperature of

[4] BOSWELL, V. R. SWEETPOTATO PRODUCTION IN KYUSHU. Memo. for Record, Agr. Div., NRS, GHQ, SCAP. February 25, 1946. Material for this section was taken largely from this paper.

55° to 59° F. Failure to hold storage temperatures at this level also causes loss.

Large numbers of growers dry portions of the crop as soon after harvest as conditions permit. When the roots are dried for feed or industrial use, they are washed and cut with a knife or rotary slicer into thin slices. The slices are spread into a thin layer on straw mats and dried in the open air on clear days. After the slices become brittle, they are bagged for storage and sometimes ground before bagging. It usually takes about 7 days for the material to dry during the late fall. When dried for food, the roots may be cooked by boiling, cooled, and allowed to become firm for a day. They are then sliced and dried.

Of the diseases that attack sweetpotatoes, black rot (*Endonconidiophora fimbriata*) is the most serious in Kyushu, as well as elsewhere in Japan. Losses from this disease in the Kanto district often range from 10 to 15 percent. The most serious losses are of roots in storage. The Japanese recommendation for control is to treat the roots immediately, before they are bedded, by immersion for 40 minutes in water maintained at 116.6° to 118.4° F. This treatment is said to be effective in the destruction of surface organisms as well as those slightly beneath the surface. It is therefore claimed to be preferable to bichloride of mercury, which is effectively used in the United States. However, the hot-water method is so troublesome to apply that Japanese farmers have seldom used it in the past. Strong efforts are being made to extend the practice.

Potatoes Prefer the Cooler Sections

Potatoes, so-called white or Irish, have reached their maximum development in Hokkaido and the northern half of Honshu, where cool climatic conditions prevail. They are of little importance in southwestern Japan, except in some of the higher mountain valleys. In Nagano Prefecture in the Tozan district, they are grown above 1,500 feet in elevation. Potatoes were grown in Japan on an average of 478,600 acres during 1941–45. The yearly production averaged 73,200,600 bushels.

The amount of fertilizer recommended per acre of land for potatoes by the Hokkaido Potato Experiment Station at Shimamatsu was as follows: Nitrogen, 65 pounds; phosphoric acid, 65; and potash, 35 to 65 pounds. There were no potassic or phosphatic fertilizers used on potatoes in 1946. Applications consisted of only about 10 pounds of nitrogen, some wood ashes, and 1.5 to 5.0 tons of manure or compost per acre. Potatoes for seed are usually fertilized less heavily and harvested earlier than are those grown for food.

Before World War II, most of the seed potatoes planted in Old Japan (Honshu, Kyushu, and Shikoku) came from Hokkaido, where they were grown under comparatively virus-free conditions. During the war period, growers found that they could grow virus-free seed locally in the higher mountain valleys. Most of the patches observed in 1945 in Honshu were heavily infected with mosaic and possibly other virus diseases. There were 10 to 50 percent, or more, of diseased plants in various fields.

White potatoes are generally grown on uplands. The seed is planted 2.0 to 2.5 inches deep, with the rows slightly ridged. They are usually planted in May and harvested in October. Seed pieces are much smaller than those used in the United States. Pieces as small as 4 grams were being planted in Okayama Prefecture in an effort to economize on seed.

The heavy infection of mosaic and other virus diseases in most fields of potatoes in Honshu in 1946 was attributed largely to the neglect of seed stocks during World War II (1941–45). Reluctance to rogue out infected plants during the war has resulted in drastic reductions in yields. Attempts were being made in 1946 to produce virus-free seed in some of the higher mountain valleys.

Possibilities for Increased Production

The facts gathered during the first year of the military occupation of Japan have revealed relatively few defects in the Japanese Government program for the maximization of indigenous food production. The average yields per unit area are already among the highest in the world. Increased production of the five principal field crops, on which the food supply of the country is so heavily dependent, should be attained wherever that is possible.

The most practical immediate means of increasing food production is by providing more nitrogenous, phosphatic, and potassic fertilizers. There is some hope of increasing the acreages of wheat, barley, potatoes, and other cool-season crops in the high-altitude regions of Honshu above 4,000 feet in elevation. Adequate preservation of perishable food crops, such as sweetpotatoes and potatoes, is another important way to provide more indigenous food for the people.

These and many other problems can probably be solved over a period of years. For the next 5 to 10 years, however, Japan will have to import from 15 to 20 percent of its food requirements in order to feed the 75 million people an average caloric intake of 2,100 to 2,200 calories per person per day.

"Cocona"—A Desirable New Fruit

by JOSEPH L. FENNELL

A new fruit, having the economic value of the cocona, is truly a fortunate acquisition to warm-climate horticulture. For the humid Tropics it would seem the answer to a long-felt need for tart preserving fruits of the temperate-climate type. Though it is beside the point of the moment, we cannot help but wonder how this strikingly beautiful and useful fruit, which is so delicious in preserves, pies, and sauces, could for so long have evaded the horticulturalists' grasp. That it has is ample proof that our work of plant exploration is by no means complete.

Should we ever have wondered if there might yet be some very desirable, but as yet undiscovered, fruit hidden within the verdant jungles of the Torrid Zone, a rare "jungle apple" or "peach tomato," so to speak, the cocona would be a good answer in the affirmative. Recently acquired from the little-explored reaches of the upper Amazon, the cocona (*Solanum hyporhodium*) constitutes a definite gain in tropical fruiticulture.

Fruit variation within this species is pronounced. The berries of various wild selections may vary in size from about 1 inch in diameter to nearly 4 inches. In form they range from ovoid, or even oblong, to round and oblate. The color of fully ripe fruits may vary with the selection from clear yellow to a deep purple red. We have selected, as the most promising for horticulture, the large-fruited types, since they are less seedy and there is more rind flesh, the part most desirable for culinary uses.

In addition to its immediate usefulness, which will be more fully discussed in later paragraphs, the cocona offers us the basis upon which to build through breeding and selection a garden fruit of outstanding economic importance. Its potentialities become truly impressive when one understands the superior characteristics of this plant and its nearest relatives.

To what extent, if any, the cocona may have reached the gardens of the outside world is difficult to say. That it appears even now to be essentially unknown to horticulture leads one to believe, in light of its impressive appearance and apparent usefulness, that it may never have previously left its secluded habitat as a recognized fruit of value. Credit for the initial step from the wilderness to the garden—collection of the plant from the wild—is due staff members of the Tingo María Experiment Station of Peru.

Cocona plants grow to a height of 4 or 5 feet, having a coarse sprawling shrublike growth with very large leaves. It is completely spineless and has prospered in full sunlight at Turrialba, Costa Rica.

The ovoid fruits, which are suggestive of large red or yellow apples, are held in compact clusters close to the trunk and branches. The plants are heavily productive, ofttimes being loaded down with from 40 to 60, or more, pounds of fruit. About 7 months are required from planting to first harvest. Ripening may then continue for several months.

Upon reaching maturity, cocona fruits turn from the earlier bright-yellow to deep-red or burnt-orange color and are then most attractive. At this stage the peachlike fuzz which is typical of this tribe of edible large-berried fruits of the genus *Solanum* is easily brushed off, leaving a clear and blemish-free skin.

The flesh and inner pulp is of a pale-cream color throughout, a fact which readily distinguishes this fruit from its two nearest relatives, the naranjilla and lulita, the pulp of which is a translucent green color.

Although the flavor of uncooked coconas is agreeable, the pulp is distinctly acid, and they are not recommended for eating out of hand. When peeled as an apple and used entire for making preserves, pies, and sauces, the product might be compared with that of apricot, pineapple, or gooseberry.

Red-ripe "cocona" fruits ready for cooking.

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Cocona marmalade and preserves are a rich translucent orange in color, and their tart and spicy flavor is both delicious and distinctive. One can safely say that there are few fruits available to the warm humid sections that can equal or surpass the better forms of this fruit for such culinary uses.

Improvement Possibilities

As an economic commodity, from the long-range viewpoint, obviously the cocona offers much in way of improvement potential. The complementary values afforded by the various closely related species of this section of the genus are not commonly available to most crop-improvement projects. It now remains for us to devise a way to blend and proportion these values satisfactorily toward developing the end product of superior hybrid combinations.

Indispensable, perhaps, to any plan for improvement of the cocona are several closely related species, such as *Solanum quitoense*, *S. hirsutissimum*, *S. hirtum*, and others. These would seem to offer a good complement of the fruit and plant characteristics most needed for genetic improvement.

Solanum quitoense is the plant known and cultivated as naranjilla and lulu in the more northern Andean regions of South America. In the highlands of Ecuador and southern Colombia the naranjilla is highly prized as a juice fruit and constitutes an important economic commodity.[1] It is found wild from Costa Rica to Peru.

Unfortunately, this species has seldom prospered in other regions, owing largely to sensitivity to environment. At Turrialba, Costa Rica, the naranjilla must be grown in half shade and has not relished high temperatures or dry soils. The ripe fruits are aromatic and acid though low in sugar. Keeping or shipping qualities are only fair.

The lulita, of the species botanically known as *S. hirsutissimum*, is occasionally found in the warmer and dryer parts of Costa Rica and Panama and as far south as Peru. It is little known either horticulturally or botanically. At Turrialba it prospers in full sunlight and has withstood considerable drought. The fuzzy or hairy fruits are about the size and shape of a hen's egg and when ripe show a rich orange color. The plants are extremely spiny.

With full maturity, fruit of the better lulita selections is quite agreeable, being aromatic, juicy, and tart with a flavor suggestive of plums. With certain refinements, this species could become truly desirable for eating out of hand. In general, the fruits indicate a higher sugar content than do either the cocona or the naranjilla, although they are typically quite seedy. The better strains of this species might contribute admirably to a breeding project in way of fruit and cultural assets.

A comparison of the breeding values of the species is offered below:

Item	Cocona	Lulita	Naranjilla or Lulu
Major cultural fault or asset	Prospers in full sunlight. Resists moderate drought and high temperatures.	Prospers in full sunlight. Resists moderate drought and high temperatures.	Requires shade and considerable moistue at low elevations. Prefers temperatures below 85° F.
Fruit size and type	3- to 4-in. diameter. Thick edible rind. Seeds not objectionable.	1½-in. diameter. Thin tough rind. Very juicy and seedy.	2 to 2½-in. diameter. Moderately juicy. Thin rind.
Flavor and best use	Acid. Preserves, pies, and jelly.	Acid aromatic. For drinks and fresh dessert fruit.	Acid aromatic. Juice and breakfast fruit.
Best genetic value	High production. Large fruit. Ease of cultivation. No thorns Keeps well.	Aromatic flavor. Sugar content.	Aromatic flavor.
Major genetic fault	Flat acid flavor. Lacks sugar.	Small fruit. Seedy. Very thorny.	Lacks sugar. Keeps poorly. Sensitive to environment.

Our preliminary efforts to hybridize these species have resulted in little encouragement to date. Fruit setting from pollinated flowers has not been too difficult to accomplish, although the seeds obtained generally have been poorly developed and in all cases have failed to germinate. The mere fact, however, that in a few instances plump seeds were formed affords some hope that ultimate success may be possible.

In any event, a safe assumption is that even in its present unimproved state the cocona is a permanent acquisition as a valuable horticultural plant. Anyone who has seen it, or has eaten the appetizing culinary products made of it, will testify to that. The possibilities of its culture in temperate climates must yet be determined.

[1] McCann, Lewis P. ECUADOR'S NARANJILLA—A RELUCTANT GUEST. Agr. in Americas 7: 146–149, illus.

INTERNATIONAL *Agricultural News*

Aid Mission to Greece Makes Progress

The American Mission for Aid to Greece began its work about a year ago in that country. After 5 or 6 months of operation, the agricultural work began to

give results. Farm machinery, fertilizers, and pesticides were distributed, and several land-reclamation and irrigation projects were either partly or entirely completed. Consequently, cultivated areas this year almost reached the prewar average; excellent crops were in prospect. A large number of specific agreements have been concluded between the Mission and the Greek Government for rehabilitation projects, and several intensive training courses have been established for Greek personnel in such fields as research, farm machinery, rural education, extension, home demonstration, artificial insemination, seed production, forestry, and the like.

Of the 10 specialists originally assigned to the Agricultural Division of the Mission, several are still carrying on their work. Among them are Clayton Whipple, formerly Acting Chief, Regional Investigation Branch, OFAR; Print Hudson, who was Agricultural Attaché at Athens; and J. D. Pope of the Department's Extension Service. Others, who acted in advisory capacities to the Greek Government were: J. Orr, Assistant to the Under Secretary of Agriculture, and M. L. Wilson, Director of Extension Service.

The expectation is that the agricultural program of the Mission will now be continued under the European Recovery Administration.

International Poultry Congress In Denmark

The Eighth World's Poultry Congress will be held at Copenhagen, Denmark, August 20–27, 1948, according to Hogsbro Holm, Secretary General of the Danish Executive Committee of the Congress, under the patronage of His Majesty, King Frederik IX. The Poultry Congresses are triennial meetings of the World's Poultry Science Association, organized in 1912 and composed of leaders of the world's poultry industry. The First Congress was held in the Netherlands in 1921. The last Congress, the Seventh, held at Cleveland, Ohio, in July 1939, was one of the world's largest agricultural gatherings.

This year only the host country, Denmark, will present an exhibit. The rest of the Congress will consist of scientific sessions. There will be approximately 135 papers presented as a major part of the program. These papers have been prepared by 164 scientists, educators, government officials, and industry leaders representing 17 different countries. Approximately 500 people, from at least 25 different nations, are expected to attend. This number includes a delegation of approximately 75 from the United States.

The Department of Agriculture delegation consists of W. D. Termohlen, Director, Poultry Branch, Production and Marketing Administration, who is chairman of the United States delegation; Nathan Koenig, Executive Assistant to the Secretary of Agriculture; H. L. Shrader, Extension Service; Paul Zumbro, Bureau of Animal Industry; John Scanlon, Farm Credit Administrator; and Smith Kimball, Bureau of Agricultural Economics.

The proceedings of the Congress will be published by the World's Poultry Science Association.

THE GUAVA

The guava (*Psidium guajava*) is a prominent member of the myrtle family, which includes the eucalyptus and many of the spices, such as clove, cinnamon, allspice, and nutmeg. It is a native of the American Tropics but has spread to other areas where frosts are light and rainfall sufficient to support its vigorous growth. In continental United States it is grown in southern California, Texas, the Gulf coast, and Florida, but is of little commercial importance.

The plant is a treelike shrub that sometimes reaches a height of 25 or 30 feet. The slender trunk is covered by a scaly, greenish-brown bark. The flowers are white, about an inch wide, and occur singly or in clusters of two or three upon a slender stem. The plant is prolific and ripens its fruits over a long period. In the West Indies and Florida harvesting is done in late summer and autumn. Seedlings bear fruit at 3 or 4 years of age, and budded plants may begin to bear the second year after planting.

Guava fruits vary from round- to pear-shaped and are from 1 to 4 inches in length. The skin is usually yellow, with the flesh ranging from white to salmon red in color. Numerous small hard seeds are embedded in the soft pulp toward the center of the fruit. The flesh is sweet, slightly acid in taste, and has a pronounced musky aroma when the fruit is ripe.

Guavas are eaten in many ways: Sliced, with cream, like bananas; stewed or preserved; out-of-hand, like a pear; or in shortcakes and pies. Commercially the greatest use for the fruit is for jelly. Properly made jelly is of a deep wine-red color, of firm consistency, and retains some of the pungent flavor of the fresh fruit. In Brazil, a thick jam is made and sold, and in the West Indies and Florida small quantities of a similar product, called guava paste, are made.

The guava contains vitamins A and B and is exceptionally rich in vitamin C. Powder made from the dehydrated fruit was used to fortify jams and jellies made from other fruits for use by the armed services during the war. The ascorbic-acid content of the juice makes it a good substitute for orange or tomato juice. Because of fruitfly infestation, rigid quarantine restrictions exist against the importation of the fresh fruit into the United States. In 1947, however, 56 short tons of guava products were imported from Cuba.

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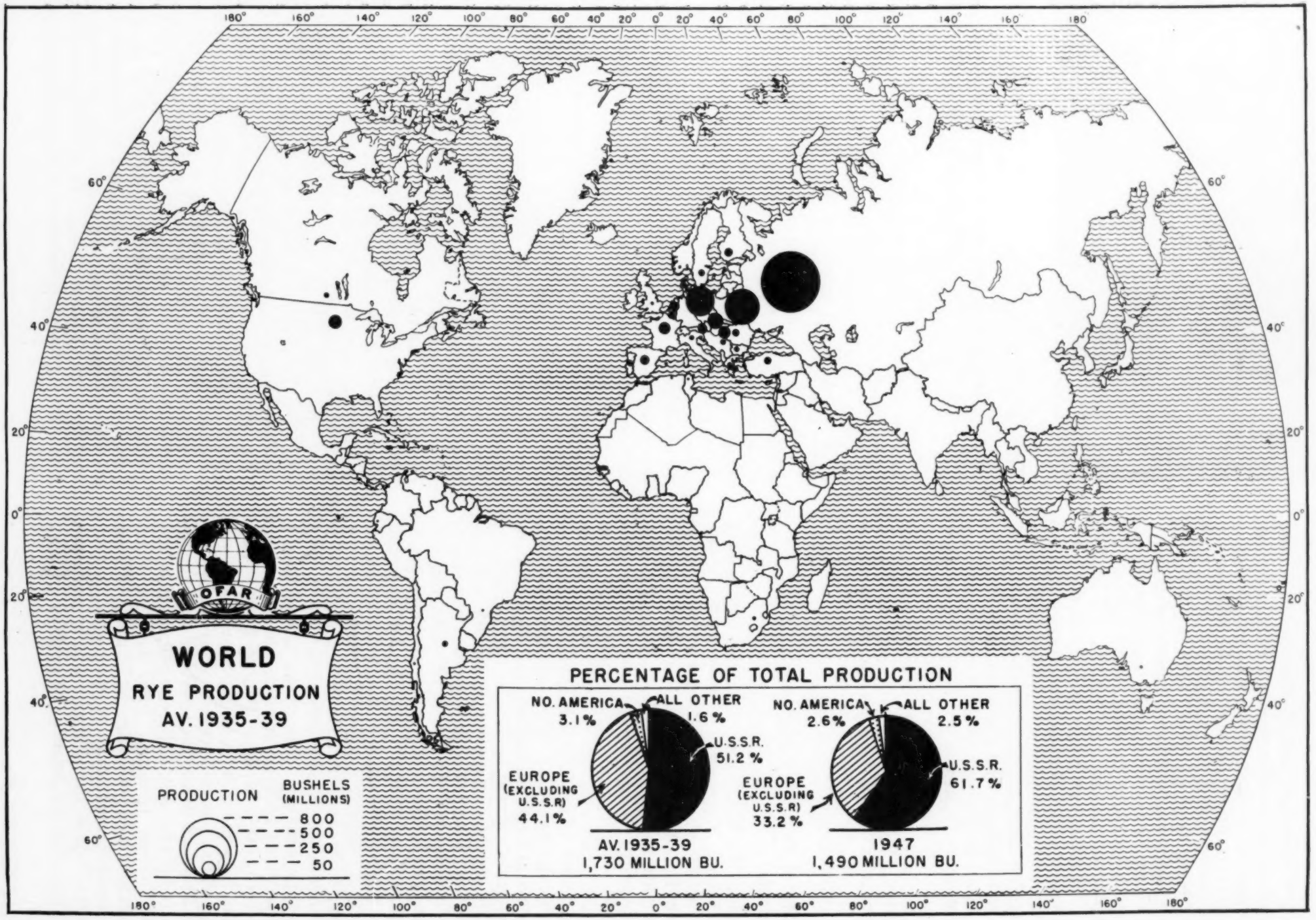

More than 95 percent of the world's rye crop is produced in Europe and the Soviet Union. The principal producing countries are the Soviet Union, Poland, Germany, and Czechoslovakia. Most of the remainder is grown in the United States, Argentina, and Canada. Rye is the principal bread-making grain of the marginal areas of the earth where soil and climatic conditions are unfavorable for wheat.

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